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Interest of Cardiac Rehabilitation in Patients with Heart Disease in a Cardiology Department in Senegal

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Abstract

Cardiac rehabilitation helps improve the prognosis and quality of life for patients with heart disease. To show its interest in the African context, in the management of heart disease, a prospective study was carried out. Its objective was to evaluate the effects of physical rehabilitation on cardiac function. **Methods:** Patients were evaluated at the beginning and at the end of cardiovascular rehabilitation by cardiovascular, biological, and echocardiographic parameters including the size of the heart chambers, the kinetics of the walls, and the systolic function of the ventricles. **Results:** The study involved 12 patients, 67% of whom were men. After cardiac rehabilitation, the mean hemodynamic constants had not been significantly modified. However, a significant decrease in Total-Cholesterol, LDL-Cholesterol and triglyceride levels was noted. Mean fasting blood sugar decreased from 1.25 ± 0.48 g/L to 0.92 ± 0.18 g/L and glycated hemoglobin from 7.72% ± 0.01% to 6.45% ± 0.008%. The echocardiographic parameters studied showed an improvement in the dilation of the heart chambers in 8.33% of the patients, the normalization of the ejection fraction of the left ventricle in 16% patients, the improvement of the kinetic disorders in 16% of patients and recovery of right ventricular systolic function in all patients. **Conclusion:** Cardiac rehabilitation as a secondary preventive measure for cardiovascular disease has contributed significantly to improving the clinico-biological parameters of the disease.

Keywords

Cardiac Rehabilitation, Heart Disease, Cardiovascular Disease

1. Introduction

Cardiovascular diseases (CVD) are a major factor of morbidity and mortality worldwide, accounting for about 50% of deaths from non-communicable diseases (NCD) [1], of which 80% occur in low- and middle-income countries. The burden of NCD and CVD is increasing in sub-Saharan Africa (SSA) [2]. Heart failure (HF) is a common terminal complication of these CVD. In SSA, heart failure mainly affects young economically active adults, resulting in impaired quality of life and loss of productivity for patients, their families and society in general [3] [4]. In Senegal, the prevalence of heart failure was estimated at 14.28% in 2019 [5]. However, many advances have been made in their management, including cardiac rehabilitation (CR). CR is defined as "the sum of activities required to influence favorably the underlying cause of the disease, as well as to provide the best possible physical, mental and social conditions, so that the patients may, by their own efforts, preserve or resume as normal a place as possible in the community" [6]. CR has helped to improve the functional prognosis and quality of life of patients with these heart diseases in high-income countries. It could represent an important approach to mitigate the epidemic of CVD in low-resource settings such as SSA [4] [7] [8]. Although there is substantial evidence of the benefits of exercise-based rehabilitation in the prevention and management of cardiovascular diseases, it is very underused in SSA. It is often under-prescribed and has low adherence rates. The commonly cited barriers to its use and the drivers of early dropout of participants are poor referral systems and inaccessibility of rehabilitation centers [2] [7] [9] [10] [11]. Apart from urban areas, there has been little development of CR in sub-Saharan Africa [12]. For instance, in regions such as western Kenya, where the burden of HF is high, CR programs are nonexistent [3]. The same is true in Senegal, where there is only one public cardiac rehabilitation center located in the capital and established in 2015. To demonstrate its interest in the management of heart diseases, a prospective study was conducted with the aim of assessing the effects of physical rehabilitation on cardiac function in patients with heart diseases in Senegal.

2. Material and Methods

The study was conducted at the cardiac rehabilitation unit of the cardiology department of the Dalal Jamm Hospital in Dakar and the Laboratory of Physiology and Functional Explorations of the FMPO of the Cheikh Anta Diop University of Dakar. It was a prospective descriptive and analytical study conducted over a period of five months from July 1 to November 31, 2021. The study population consisted of any consenting adult patient with a cardiac pathology indicated to participate in the cardiovascular rehabilitation program. Patients who stopped the program due to deterioration of their health or who abandoned the rehabilitation program for personal reasons were excluded. Sociodemographic and clinical data were collected from the study population. Patients were evaluated at the beginning and end of cardiovascular rehabilitation by cardiovascular parameters, including systolic and diastolic blood pressures (SBP, DBP), mean arterial pressure (MAP), and heart rate (HR); biological parameters (hemogram, renal and lipid balance, fasting glycemia, glycosylated hemoglobin); and echocardiographic parameters (dimension of cardiac cavities, wall kinetics, and systolic function of the ventricles).

The protocol of cardiac rehabilitation (CR) involved several steps: first, a comprehensive initial assessment to stratify the patient's risk and adapt the modalities and monitoring of CR. This initial assessment included a clinical examination with a history and a complete physical examination, a biological assessment of cardiovascular risk factors, an electrocardiogram, a transthoracic echocardiography, and a triangular exercise test on a bicycle with an increase of 25 Watt per minute. This allowed to determine the level of retraining, the initial load, the heart rate (HR) at maximal effort (HRmax) and the HR of retraining (HRR) according to the Karvonen formula:

$$\text{HRR} = \text{HRrest} + \text{K}\left(\text{HRmax} - \text{HRrest}\right);$$

K = 0.6 if patient without beta-blocker and 0.8 if with beta-blocker [13].

Then, the second step consisted of starting the CR sessions with 3 sessions per week after a warm-up of 5 to 10 minutes. Each retraining session had two phases with a prescribed load after risk and functional capacity assessment, first on a bike for 15 to 30 minutes then on a treadmill for 15 to 30 minutes, followed by a recovery phase of 3 to 5 minutes. The Borg scale was used during the retraining sessions to measure the perception of effort. The average number of CR sessions was 15 to 20 sessions.

Finally, the third step consisted of evaluating the effect of the cardiovascular rehabilitation program by conducting a post-rehabilitation assessment. A physical examination was performed with a measurement of cardiovascular parameters and a biological assessment. Additionally, cardiac function and functional capacity were evaluated respectively by echocardiographic assessment and a final exercise test to determine the theoretical maximum heart rate (MHR) achieved and the training heart rate (THR). Patients also received education sessions and advice on nutrition.

Data analysis was performed using Graph Prism version 5 software. Quantitative data were expressed as means +/− standard deviation. The T-Test was used to compare these quantitative data between the period before and after rehabilitation. As for qualitative variables, they were expressed as proportions and the Chi-square test was used to evaluate the impact of cardiovascular rehabilitation. The significance level was set at $p < 0.05$.

3. Results

Out of the 17 registered patients, 4 patients interrupted the rehabilitation, 1 patient had decompensation during the program, and 12 finished their session and benefited from their final assessments. They consisted of 67% men with a sex ratio of 2.04, and the average age was 63.08 ± 7.57 years (Table 1). The different risk factors found among the participants were mainly sedentary lifestyle (100%) and hypertension (83%), followed by diabetes and obesity (42%) (Figure 1).

Among the patients, 75% had coronary artery disease, 16% had hypertension, 8% had dilated cardiomyopathy (DCM) of unknown etiology, and 8% had obstructive sleep apnea syndrome (OSAS).

Regarding cardiovascular parameters, it was found that the mean hemodynamic constants were not significantly modified after cardiac rehabilitation. However, there was a significant improvement in the body mass index measured at the beginning and end of the rehabilitation protocol. Indeed, the mean BMI

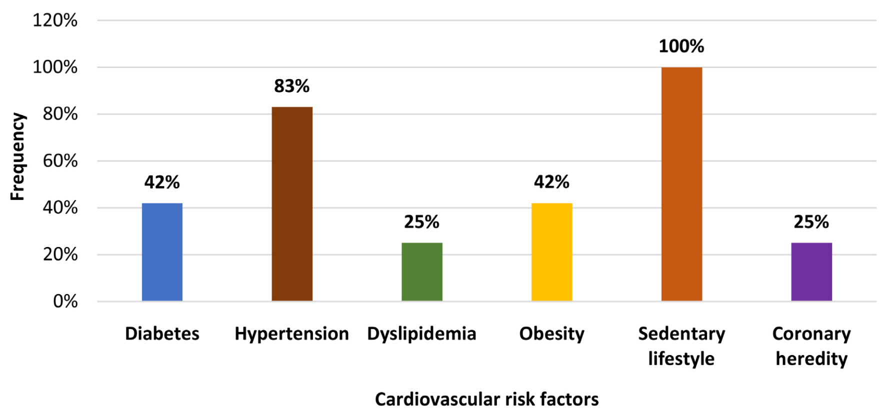

Figure 1. Different risk factors found in patients.

Table 1. Characteristics of patients indicated for the cardiovascular rehabilitation (CR) program.

PATIENT CHARACTERISTICS		VALUES
Number of registered participants		17
CR interruption		4
Decompensation during CR		1
Number of participants having finished CR		12
Sex		67% Men/33% Women
Average age		63.08 +/− 7.57 years
DIAGNOSIS	Coronary artery disease	75%
	Hypertension	16%
	DCM	8%
	OSAS	8%

DCM: Dilated Cardiomyopathy; OSAS: Obstructive Sleep Apnea Syndrome.

decreased from 27.14 ± 3.28 to 25.1 ± 2.19 after physical training sessions ($p = 0.004$). There was no significant difference in the mean values of the hematogram elements before and after rehabilitation.

The renal assessment performed on patients before and after rehabilitation did not show a significant modification. However, between the beginning and the end of the rehabilitation, there was a significant decrease in the total cholesterol level, which decreased from 1.74 to 1.52 g/L ($p < 0.0001$), the LDL-cholesterol level, which decreased from 1.09 g/L to 0.92 g/L ($p = 0.0047$), and the triglyceride level, which decreased from 1.10 g/L to 0.98 g/L ($p = 0.0083$). Moreover, the HDL-cholesterol level did not have a significant modification.

The glycemic assessment of patients after rehabilitation showed a significant difference. Indeed, the average fasting blood glucose level decreased from 1.25 ± 0.48 g/L to 0.92 ± 0.18 g/L ($p = 0.0499$), and the glycosylated hemoglobin level decreased from 7.72% ± 0.01% to 6.45% ± 0.008% ($p = 0.0441$) (Table 2).

Table 2. Physical and biological parameters improved during cardiac rehabilitation.

Parameters studied	Cardiac rehabilitation		p value
	Before	After	
Cardiovascular parameters			
SBP (mmHg)	131.3 ± 15.5	125 ± 9.5	0.2097
DBP (mmHg)	77.4 ± 7.25	77.5 ± 3.5	0.9789
MAP (mmHg)	95.4 ± 9.65	93.4 ± 4.5	0.5554
HR (bpm)	72.5 ± 9.65	70.6 ± 7.5	0.3851
Weight (kg)	78.25 ± 10.96	75.24 ± 10.95	**0.004**
BMI (kg/m^2)	27.14 ± 3.28	25.1 ± 2.19	**0.004**
Hematological parameters			
Hemoglobin (g/dL)	12.7 ± 1.03	12.6 ± 0.51	0.8349
Hematocrit (%)	47.8 ± 2.08	46.8 ± 1.38	0.1388
Red Blood Cells (elements/mm^3)	5.63 ± 1.02	5.47 ± 0.96	0.9864
White Blood Cells (elements/mm^3)	6.63 ± 1.02	6.56 ± 0.83	0.8031
Platelets (elements/mm^3)	344.9 ± 81.5	388 ± 68.1	0.4884
Biochemical parameters			
Fasting blood sugar (g/L)	1.25 ± 0.48	0.92 ± 0.18	**0.0499**
HbA1c (%)	7.72 ± 0.01	6.45% ± 0.008	**0.0441**
Urea (g/L)	0.319 ± 0.06	0.325 ± 0.048	0.5344
Creatinemia (mg/L)	11.65 ± 3.43	10.81 ± 2.66	0.1745
Ch-T (g/L)	1.74	1.52	**0.00098**
LDL-C (g/L)	1.09	0.92	**0.0047**
HDL-C (g/L)	0.46	0.48	0.547
TG (g/L)	1.1	0.98	**0.0083**

The echocardiographic parameters studied showed after the rehabilitation program, an improvement in the dilation of cardiac cavities in 8.33% of patients, normalization of the left ventricular ejection fraction (LVEF) in 16% of patients with moderately reduced LVEF at the beginning, improvement in kinetic disorders in 16% of patients, and recovery of right ventricular systolic function (RVSF) in all patients with RVSF alteration at the beginning. Thus, there was a significant improvement in systolic heart function, considering the mean LVEF which increased from 51% to 57% ($p = 0.00588$) (**Table 3**). A better physical ability of patients was observed after the rehabilitation program. Indeed, the mean functional capacity of the study population increased from 6.58 ± 3.2 to 8 ± 3.4 Mets ($p = 1.96 \times 10^{-5}$). A significant improvement in cardiac reserve was observed at the end of the retraining protocol (74% vs 85%; $p = 0.0011$).

4. Discussion

Our study showed that cardiovascular rehabilitation has beneficial effects in patients with heart disease. Our results are consistent with the literature. Indeed, the five main cardiovascular risk factors found in our population (sedentary lifestyle, hypertension, diabetes, obesity, and dyslipidemia) had been identified by the INTERHEART AFRICA study as responsible for 89.2% of the risk of myocardial infarction in the African population [13]. These same factors were found by Pavy *et al.* [14]. The mean age of our patients (63.08 ± 7.57 years) was comparable to that of the Moroccan study, which was 56.57 ± 10.2 years with a male predominance (87.5%). Similarly, coronary artery disease was the most frequent

Table 3. Cardiac morphological and hemodynamic parameters improved during cardiac rehabilitation.

Parameters		Cardiac rehabilitation		P value
		Before	After	
Left Ventricular Ejection Fraction (LVEF)	Reduced	17%	9%	0.73
	Moderately Reduced	**25%**	**9%**	**0.043**
	Preserved	**58%**	**84%**	**0.047**
	Average	51%	57%	0.89
Kinetics of the walls of the Left Ventricle	Kinetic disorders	58%	42%	0.736
	Normal	42%	58%	0.85
Systolic function of the right ventricle (RVSF)	Impaired	**16%**	**0%**	**0.005**
	Normal	84%	100%	0.96
Exercise Test Parameters	Average Functional Capacity (Watts)	**99.08 ± 22.05**	**123.08 ± 22.07**	**1.96×10^{-5}**
	Theoretical Maximum Frequency reached	**75%**	**85%**	**0.0011**

indication in this study (75%) [15], as well as in the study by Kinic *et al.* (61.5%) [16]. In the EUROACTION study where patients were followed up for one year, participation in the rehabilitation program was also associated with better control of obesity and overweight [17]. Another study conducted in Johannesburg, South Africa, also reported a reduction in weight and skinfold thickness after 6 months in patients who complied well with the program [18]. Prolonged and regular endurance training facilitates weight loss, improves the distribution of perivisceral fat, and contributes to the reduction of abdominal circumference.

A similar improvement in lipid and glycemic profile during rehabilitation was also found by Pavy *et al.* and in the EUROACTION study [14] [17]. It is known that aerobic and resistance physical exercise beyond a few weeks contributes to improving the lipid profile. Exercise retraining is associated with a decrease in LDL cholesterol and a modest increase in HDL cholesterol. Moreover, physical exercise leads to an improvement in insulin resistance index, reduces hyperinsulinemia and insulin requirements. In general, better glycemic control is observed with physical activity. Physical exercise in cardiac patients has a beneficial effect widely demonstrated in many studies [19] [20] [21] [22] [23]. They showed an improvement equivalent to treatment with beta-blockers [11] [24] [25]. As for cardiac systolic function, the studies by Mouine N. [15] and Rhissassi [26], had reported a marked improvement in LVEF after a cardiovascular rehabilitation program. Indeed, rehabilitation allows, in the long term, to improve systolic function estimated by ejection fraction, ventricular filling parameters and diastolic function in general, and to reduce the effects of ventricular remodeling.

From a physical fitness perspective, our results were consistent with those of Rhissassi in his study, which found an average functional capacity of 6.58 ± 3.2 Mets at the initial evaluation and 8 ± 3.4 Mets at the end of a physical retraining program [26]. Manzoni *et al.* also found similar results in their population of coronary patients with a 30.3% improvement in physical fitness after the rehabilitation program ($p < 0.001$) [27]. These data suggest that rehabilitation through exercise retraining would improve the patient's functional capacity and functional prognosis. Indeed, the beneficial effects of exercise training occur at different levels, on the cardiocirculatory function, skeletal muscle performance, and respiratory function. They include blood and neurohormonal metabolic effects. The improvement of peripheral muscle function plays a major role. It results from an increase in blood perfusion, capillary density, improvement of oxidative enzymatic activity, and an increase in mitochondrial density. For the past twenty years, the vascular endothelium has emerged as a key element in the circulation of peripheral and coronary blood vessels [23] [28] [29] [30]. Indeed, endothelial dysfunction is considered the primum movens of various cardiovascular pathologies. It is present in both coronary and heart failure pathologies.

Regular physical exercise could cause an increase in shear forces, also called "shear stress", which act on endothelial mechanoreceptors and would stimulate the production of endothelial NO synthase (e-NO synthase). This mechano-hormonal transduction involves phosphorylation, acetylation, and coupling/

uncoupling phenomena. This could lead to the local release of NO, which is considered the most powerful vasodilator in the body [28]. This increased release of NO would be responsible for improving circulation and allowing the cardiovascular system to increase its physiological functions such as systolic ejection or good diastolic filling. Regular physical activity could also lead to a reduction in the release of oxygen-derived free radicals (ROS: Reactive Oxygen Species). Moreover, the activation of e-NO synthase induced by physical training, in association with mobilization factors of vascular endothelial growth factors (VEGF) and metalloproteinases, is also involved in the processes of neovascularization and angiogenesis [28]. The production of neovessels in the body would improve physical fitness and reduce cardiovascular risk [20]. Authors have also reported that any gain in functional capacity of 1 Mets (3.5 ml/min/kg of oxygen) would be accompanied by a decrease in mortality of nearly 15% [11].

5. Study Limitations

Our study has some limitations that should be taken into account when interpreting the results. First, the cardiorespiratory exercise test based on the analysis of respiratory gas evolution was not performed in our patients due to the unavailability of the equipment. Second, markers such as eNO, ROS, VEGF, etc., were not evaluated, which could have provided additional insights into the physiological mechanisms underlying the observed effects. Finally, the study population was small, which may limit the generalizability of the findings to other populations. Despite these limitations, our study provides valuable information on the effects of cardiac rehabilitation on cardiovascular risk factors and functional capacity.

6. Conclusion

In conclusion, the cardiac rehabilitation program has a beneficial effect on aerobic capacity, improves cardiovascular risk factors and quality of life, and reduces cardiovascular morbidity and mortality. Exercise retraining should be considered, by the cardiologist and the patient, as an integral and indispensable element of the overall treatment of heart diseases. Individuals who follow this program have improved physical parameters such as an increase in maximum workload and a reduction in associated cardiovascular risk factors. However, the prescription rate is still low in Senegal and generally in sub-Saharan Africa, due to several obstacles ranging from the low level of reference of doctors to inadequate social support and difficulties in following the rehabilitation program. Therefore, measures should be taken to promote cardiac rehabilitation in all sub-Saharan African countries in general and in Senegal in particular.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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